

# Delevan National Wildlife Refuge

## Water Management Plan

February 9, 2011  
(final plan submittal date)

## Section A - Background

1. *Identify the staff member responsible for developing and implementing the Plan. Provide their contact information*

Name Steven R. Emmons Title Wildlife Refuge Manager  
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2. *Year refuge established* 1962

<i>Define year-type used consistently throughout plan</i> <u>USBR water year - March 1 through February 28</u>
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3. *Water supplies*

*List each annual entitlement of surface water under each water right and/or contract*

<i>Supplier</i>	<i>Water source</i>	<i>Contract #</i>	<i>Contract restrictions</i>	<i>Acre-feet/year</i>
<i>Federal level 2</i>	GCID Canal	1425-98-FC-20-17620	None	20,950
<i>Federal level 4</i>	GCID Canal	1425-98-FC-20-17620	None	9,050
<i>State</i>	NA	NA	NA	0
<i>Appropriative</i>	NA	NA	NA	0
<i>Other, riparian</i>	NA	NA	NA	0

4. *Provide a narrative on pre-CVPIA refuge water supplies and water management*

The history of water rights, contracts, and use on the Sacramento NWR Complex (Complex) is a complicated one. To summarize, until October of 1992, the Complex had no firm water supply and often suffered from lack of water availability from late November through early April.

In the mid 1980's, USBR began construction of a cross tie from Stony Creek to the Tehama Colusa Canal to divert 80 cfs to meet water contract demands from irrigation districts. The Refuge was promised utilization of any or all of this 80 cfs pending other current requests. The crosstie was scheduled for completion in late December of 1987. Unfortunately, the plight of the winter run Chinook salmon in the Sacramento River necessitated the raising of the Red Bluff Diversion Dam gates. This shut down any water deliveries via the Tehama Colusa Canal and eliminated any possibilities for winter water for the Complex. Each year the Diversion Dam is maintained in an open position during winter, until the end of February, to allow passage of the salmon.

The Glenn-Colusa Irrigation District (GCID) serves Sacramento NWR, Delevan NWR and Colusa NWR. GCID takes its water from the Sacramento River via lift pumps near Hamilton City. A problem with the taking of salmon via these pumps has been identified since 1920. This problem remained unresolved; and on

August 19, 1991, an injunction filed against GCID by the National Marine Fisheries Service for the taking of threatened winter run Chinook salmon took effect. GCID's pumping at the Hamilton City plant was immediately reduced from approximately 2,300 cfs to 1,100 cfs. This amount has since been increased due to work done by GCID to improve the efficiency of their fish screens at the Hamilton City pumping plant.

Prior to the CVPIA contract agreement between the USBR and GCID along with associated upgrades GCID made to their water delivery system as a result of the agreement, water deliveries to Sacramento NWR, Delevan NWR and Colusa NWR were limited primarily to the months of April through November. Generally, GCID shut down the main water delivery system to Delevan NWR (Hunter Creek 2A) for maintenance beginning in late November of each year. Usually, water deliveries would resume beginning in mid- to late March of the following year. As a result, typical management strategy for the refuge's wetlands at that time was to ensure the wetlands were flooded to near maximum capacity prior to Thanksgiving to ensure units would continue to retain water throughout the GCID shut-down period during years with lower winter rainfall amounts. Although this management strategy generally ensured wetlands were available throughout the winter, the wetlands were often not maintained at an optimum (shallower) water level for use by wintering waterfowl.

5. *Land use history--Identify habitat types specific to this refuge.*

*Attach a refuge map showing habitat location and size.*

See attachment A - Delevan National Wildlife Refuge Habitat Map.

*List refuge habitat-types with 5% or more of total acreage*

<i>Habitat type</i>	<i>Original size</i>	<i>1992 acres</i>	<i>1997 acres</i>	<i>2010 acres</i>
<i>Seasonal wetland – timothy (not irrig)</i>	Not Available	3,768	3,768	3,284
<i>Seasonal wetland – timothy (irrigated)</i>	Not Available	0	0	0
<i>Seasonal wetland – smartweed</i>	Not Available	0	0	0
<i>Seasonal wetland - watergrass</i>	Not Available	531	531	803
<i>Permanent wetland</i>	Not Available	286	286	30
<i>Semi-permanent wetland/brood pond</i>	Not Available	139	139	607
<i>Reverse cycle wetlands</i>	Not Available	0	0	0
<i>Riparian</i>	Not Available	48	48	48
<i>Irrigated pasture</i>	Not Available	0	0	0
<i>Upland</i>	Not Available	1,014	1,014	1,014
<i>Upland (not irrigated)</i>	Not Available	1,014	1,014	1,014
<i>Upland (managed)</i>	Not Available	1,014	1,014	1,014
<i>Upland (grains)</i>	Not Available	0	0	0
<i>Other (&gt;5%)</i>	Not Available	0	0	0
<i>Misc. habitat (&lt;5%)</i>	Not Available	0	0	0
<i>Sub-total – habitat acres</i>	Not Available	5,786	5,786	5,786
<i>Roads, buildings, etc.</i>	Not Available	11	11	11
<i>Total (size of refuge)</i>	5,522	5,797	5,797	5,797

*Describe refuge habitat-type water use characteristics*

<i>Habitat type</i>	<i>AF/ac</i>	<i># of irrigations</i>	<i>Floodup date</i>	<i>Draw down date</i>
<i>Seasonal wetland</i>	5.0	0	8/1 – 12/1	4/1 – 6/1
<i>Seasonal wetland - timothy</i>	5.0	0	8/1 – 11/1	4/1 – 6/1
<i>Seasonal wetland - watergrass</i>	7.5	1	8/1 – 10/1	4/1 – 5/1
<i>Permanent wetland</i>	13.25	0	Continuous	Continuous
<i>Semi-permanent wetland/brood pond</i>	9.0	0	10/1 – 11//1	7/15 - 8/15
<i>Riparian</i>	0	0	NA	NA
<i>Irrigated pasture</i>	0	0	NA	NA
<i>Upland (not irrigated)</i>	0	0	NA	NA
<i>Upland (managed)</i>	0	0	NA	NA
<i>Upland (grains)</i>	0	0	NA	NA
<i>Other (&gt;5%)</i>	0	0	NA	NA
<i>Misc. habitat (&lt;5%)</i>	0	0	NA	NA

## Section B - Water Management Related Goals and Objectives

1. *Describe the refuge mission relative to water management. (i.e. crop depredation, legislative mandates, service to landowners)*

The purposes for Delevan NWR involve habitat for wetland dependent species. In this artificially created and maintained system, efficient water management is critical to accomplishing these purposes.

Purposes for this Unit:

... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds. 16 U.S.C. 715d (Migratory Bird Conservation Act)

2. *Describe specific habitat management objectives. Include pertinent information from refuge management plans*

The following habitat types are managed on the Refuge:

Seasonal wetland – swamp timothy: By far the most numerous and diverse of the wetland habitat types, these units comprise about 70 percent of the wetland habitat base and are typically flooded from early September through mid-April. Their diversity is the product of a variety of water depths that result in diverse patterns of plant species (vegetation) that, in combination, provide habitat for the greatest number of wildlife species throughout the course of a year. Through the fall and winter, seasonally flooded marshes are used by spectacular concentrations of waterfowl and smaller numbers of egrets, herons, ibis, and grebes. In addition, a full complement of raptors descends upon the waterbird prey base for their winter food supply. As water is removed in the spring, large concentrations of shorebirds utilize the shallow depths and exposed mudflats on their northern migration. Seed producing plants germinate and grow to maturity on the moist pond bottoms during the spring and early summer. Flood up in the fall makes this food available to early migrant waterfowl and other waterbirds.

Seasonal wetland - watergrass/smartweed: Comprising approximately 12 to 15 percent of the wetland habitat base, these units are typically flooded from late August through early May. An irrigation is usually

accomplished in mid-June to bring large quantities of watergrass, sprangletop, and smartweed plants to maturity. During these irrigation periods, these units are often utilized by locally nesting colonial waterbirds (herons and egrets). Because this habitat type often results in thick monocultures, openings are disked or mowed prior to flood-up. Though not as diverse, once flooded these units provide an abundant food source for waterfowl at a very important (potential crop depredation) time of the year. In addition, a number of wading bird species frequent them throughout the year.

Semi-permanent wetland/brood pond: Combined with permanent ponds, these habitats make up 5 to 15 percent of the wetland base. During the summer growing season, water is often used to encourage growth in certain sparsely vegetated units. Two water management strategies are employed: in most units, water removal will not take place until late July; in others, normal drawdown (April) is done, scheduled work is completed, and then the unit is flooded for the remainder of the year. Both practices serve to promote plant growth while providing wetland habitat for "resident" wildlife during the hot summer months.

Permanent wetland: Combined with semi-permanent wetland/brood pond, these habitats make up 5 to 15 percent of the wetland base and remain flooded throughout the year. Characterized by both emergent and submergent aquatic plants, these units provide brood and molting areas for waterfowl, secure roosting and nesting sites for wading birds and other over water nesters, and feeding areas for species like cormorants and pelicans. These units are drawn down every four to five years in order to recycle nutrients to increase their productivity and discourage carp populations.

Riparian: Comprised primarily of black willow, but with patches of sandbar willow and Fremont's cottonwood, riparian habitat occurs along the Colusa Basin Drain (2047) and other managed waterways of Delevan NWR. Willows and cottonwoods also occur sparsely in and around some managed marsh units. The larger "riparian tracts" are located in Tract A on the north boundary of the refuge, and Tract 24 Cell 2. Willows and cottonwoods provide nesting, roosting, and feeding habitat for passerine species and raptors, and shelter and screening for waterfowl. Deer, small mammals, duck broods, and giant garter snakes utilize creeks and water delivery systems during the summer, when most marsh units are dry.

Vernal pools and alkali meadows: Most plant species in these communities are natives and occur in a variety of patterns, which yield the most diverse vegetation on the Refuge. Nine Federal, State, and California Native Plant Society (CNPS) special status plant species occur in these habitats; as well as three special status invertebrates. During the wet season, cackling geese, wigeon, and coots graze on the depauperate grasses in the alkali meadows, and dabbling ducks and shorebirds feed in the vernal pools. Killdeer, stilts, and avocets nest in these habitats. Alkali meadows and vernal pools are the native, indigenous habitats of the Colusa Plains (Basin), once known as the "hard alkali gooseland." Now, areas on Sacramento NWR, Delevan NWR, and Colusa NWR are virtually all that remain of this habitat type in the region.

### *3. Describe the strategies used to attain objectives listed above*

On an annual basis a review of the previous habitat management plan is conducted, which involves a planning team visiting each habitat unit on each refuge to document the previous year's accomplishments, establish needs and develop plans for the upcoming year. These findings are compiled to produce the current year's habitat management plan for each refuge.

### *4. Describe constraints that prevent attainment of objectives and explain the effect on operations*

The habitat planning process identifies a far greater workload than can be accomplished in a single year, given present funding, staffing and existing priorities.

5. *Describe the strategies used to remedy the constraints listed above*

Continue to refine management techniques, to improve efficiency, and develop alternate/additional funding sources to help address present budget and staffing limitations.

## **Section C - Policies and Procedures**

1. *Describe the refuge policies/procedures on accepting agricultural drainage water as supply*

Delevan Refuge accepts upslope drainage water because GCID canal deliveries include upslope drainage water. Refuge flow-through practices result in habitat units that are on the refuge border releasing flow-through quantities into outflow drains. There is no formal policy or procedure concerning the quality of water that the refuge will accept. No standards have been established and no water quality testing is conducted.

2. *Describe the refuge policies/procedures on water pooling, transfers, reallocations or exchanges*

The refuge has no Sacramento NWR Complex or US Fish & Wildlife Service policies or procedures on pooling, transfers, reallocations or exchange but follows those established by the CVPIA and in the water supply contracts.

### **POOLING OF WATER SUPPLIES**

6. (a) Whenever the maximum quantities of Level 2 Water Supplies and/or the Incremental Level 4 Water Supplies depicted in Exhibit AB@ are reduced pursuant to Article 9 of this Contract, the remaining Level 2 Water Supplies and/or the Incremental Level 4 Water Supplies may be pooled for use on other Refuge(s); Provided, that no individual Refuge shall receive more Level 2 Water Supplies than would have been made available to it absent a reduction pursuant to Article 9 of this Contract; or be reduced by more than twenty-five (25) percent; Provided further, that the Contracting Officer makes a written determination that pooling of water for use on other Refuge(s) would not have an adverse impact, that cannot be reasonably mitigated, on Project operations, other Project Contractors, or other Project purposes; Provided further, that the Contracting Officer determines that such reallocation is permitted under the terms and conditions of the applicable underlying water right permit and/or license; and Provided still further, that water made available under this contract may not be scheduled for delivery outside the Contractor=s Boundary without prior written approval of the Contracting Officer.

(b) An Interagency Refuge Water Management Team, to be chaired by the Contracting Officer and to be established upon execution of this Contract, shall be entitled to collaboratively allocate the pooled water supplies and provide a schedule for delivery of the pooled supplies to meet the highest priority needs of the Refuge(s) as depicted in Exhibit AB@; Provided, however, nothing in this Article is intended to require the Contractor to pool the water supply provided for in this Contract. The Interagency Refuge Water Management Team shall be composed of designees of the Bureau of Reclamation, the United States Fish and Wildlife Service, the California Department of Fish and Game, and the Grassland Water District.

### **TRANSFERS, REALLOCATIONS OR EXCHANGES OF WATER**

7. Subject to the prior written approval of the Contracting Officer, the Project Water made available under this Contract may be transferred, reallocated or exchanged in that Year to other Refuge(s) or Project contractors if such transfer, reallocation or exchange is requested by the Contractor and is

authorized by applicable Federal and California State laws, and then-current applicable guidelines or regulations.

3. *Describe the refuge water accounting policies/procedures for inflow, internal flow and outflow*  
Irrigators estimate quantity delivered by month for individual units. Deliveries are measured by the local irrigation district at the point of delivery. A computer spreadsheet of monthly deliveries is updated by the 7th of each month and provided to USBR. The irrigator for each refuge maintains records of the flood-up and draw-down dates for each wetland unit which is recorded in the annual habitat management plan for the refuge. Outflow points have no measurement devices.

4.- *Attach a copy of the refuge's shortage policies, drought plan, or any similar document.*  
See attachment B – Delevan National Wildlife Refuge Drought Contingency Plan.

Based on established refuge purposes (see Section B1) and the projected water supply, we determine critical habitat needs and analyze existing water use records by both refuge unit and habitat type, to determine the amount, distribution and timing of each habitat unit to be flooded.

5. *(GRCD only) Describe water policies as they pertain to:*  
—— *a. water allocation policy to customers (attach);*  
—— *b. lead time for water orders (attach sample water order form);*  
—— *c. policies for wasteful use of water (attach policy); and*  
—— *d. pricing and billing policies (attach sample bills)*

<i>Fixed Charges</i>			
<i>Charges (\$ unit)</i>	<i>Charge units (\$/acre), (\$/customer) etc.</i>	<i>Units billed during year (acres, customer) etc.</i>	<i>\$ collected (\$ times units)</i>

<i>Volumetric charges</i>			
<i>Charges (\$ unit)</i>	<i>Charge units (\$/AF), (\$/HCF), etc.</i>	<i>Units billed during year (AF, HCF) etc.</i>	<i>\$ collected (\$ times units)</i>

## Section D - Inventory of Existing Facilities

### 1. Mapping

*Attach existing facilities map(s) that show points of delivery, turnouts (internal flow), and outflow (spill) points, measurement locations, conveyance system, storage facilities, operational loss recovery system, wells, and water quality monitoring locations. Describe in the body of the plan the information contained*



*in each attached map.*

The attached maps (Attachment C – Delevan National Wildlife Refuge Water Delivery and Drainage Map, Delevan National Wildlife Refuge Water Drainage Areas Map, and Delevan National Wildlife Refuge Water System Map) show points of delivery, turnouts (internal flow), and outflow (spill) points, measurement locations, and the conveyance system. Delevan NWR does not have storage facilities, an operational loss recovery system, active wells, or water quality monitoring locations, therefore, these are not shown on the attached facilities maps.

## 2. *Water measurement*

### *a. Inflow/deliveries*

*Total # of inflow locations/points of delivery* 1

*Total # of measured points of delivery* 1

*Percentage of total inflow (volume) measured during report year* 100

<i>Delivering agency</i>	<i>Conveyance facility</i>	<i>Measuring point</i>	<i>Refuge distribution facility</i>	<i>% of total inflow</i>	<i>Type of measurement</i>	<i>Measuring agency</i>
GCID	Hunter Creek 2A	HC2A	Main Distribution	100	M2	GCID

### *b. Internal flow at turnouts*

*Total # of refuge water management units (units)* 65

*Total # of refuge water management unit turnouts* 50

*Total # of measured turnouts* 0

*Estimated % of total internal flow (volume) during report year that was measured at a turnout* 0

*Number of turnouts supplying more than one unit or not directly off delivery system* 13

<i>Measurement type</i>	<i>Number of devices</i>	<i>Acres served</i>	<i>Accuracy (avg or range)</i>	<i>Reading frequency</i>	<i>Calibration frequency (months)</i>	<i>Maintenance frequency (months/days)</i>
<i>Orifices</i>						
<i>Propeller</i>						
<i>Weirs</i>						
<i>Flumes</i>						
<i>Venturi</i>						
<i>Alfalfa valves</i>						
<i>Metered gates</i>						
<i>Other, stop-log and screwgates</i>	50	4,522	Unknown	1-3 times / Week	Never	1-3 times / Week

Most water control structures are pre-cast twin-track risers with wooden stop-logs and polyethylene pipe, although a few structures have screwgates attached. During active flood-up of a unit, structures are visually



checked and readjusted if needed every 1-2 days to ensure a proper rate of flood-up is maintained to provide optimum habitat. Once a unit is flooded, readjustments are made to the structure to provide a reduced “maintenance” flow (approximately 1-3 cfs depending on the size of the wetland unit) to maintain optimal depth, at which time the structure is visually checked 1-2 times per week.

*c. Outflow*

*Outflow (AF/yr)* unknown quantity

*Total # of outflow locations/points of spill* 16

*Total # of measured outflow points* 0

*Percentage of total outflow (volume) measured during report year* 0

<i>Outflow point</i>	<i>Measuring point</i>	<i>Type of measurement</i>	<i>Percent of total outflow (estimated)</i>	<i>Measuring agency</i>	<i>Acres drained</i>
2047 drain	T25 north	None	23%	Delevan NWR	1,028
2047 drain	T25 south	None	22%	Delevan NWR	1,028
TA slough / 2047	T5.1	None	>1%	Delevan NWR	24
MID Canal	T5.2	None	3%	Delevan NWR	141
2047 drain	T5.3	None	2%	Delevan NWR	80
2047 drain	T5.5	None	4%	Delevan NWR	170
Stone Corral	East drain	None	14%	Delevan NWR	641
2047 drain	SE corner	None	20%	Delevan NWR	903
2047 drain	T31	None	1%	Delevan NWR	59
2047 drain	T35	None	2%	Delevan NWR	69
Stone Corral Ck.	T37.2	None	2%	Delevan NWR	78
2047 drain	T41	None	>1%	Delevan NWR	16
Maxwell Rd drain	T42.1	None	>1%	Delevan NWR	35
Stone Corral Ck.	T42.2	None	3%	Delevan NWR	147
2047 drain	T44.1	None	1%	Delevan NWR	60
2047 drain	T44.2	None	1%	Delevan NWR	43
			100%		4,522

*3. Identify the type and length of the refuge internal distribution system*

<i>Miles unlined canal</i>			<i>Miles lined canal</i>	<i>Miles piped</i>	<i>Miles – other</i>	
<i>Delivery</i>	<i>Drain</i>	<i>Delivery/Drain</i>		<i>Delivery</i>	<i>Delivery</i>	<i>Drain</i>
14.1	5.8	14.6	0	0.5		7.3

*Describe the location and types of identified leaks and areas of higher than average canal seepage, and any relation to soil type.*

Refuge staff has not identified any significant leaks or areas of higher than average canal seepage. No areas of high seepage due to soil type (gravel lens, etc.) have been identified.

4. *Describe the refuge operational loss recovery system*

NONE

Pump #	Location	HP

5. *Groundwater*

*Describe groundwater availability, quality and potential for use*

USBR drilled four test wells on nearby Sacramento NWR in the early 1990s. Chemical analysis of these groundwater wells at Sacramento NWR and at Colusa NWR detected mercury levels above the EPA chronic criteria (both Sacramento NWR and Colusa NWR) and levels of the hexavalent form of chromium above the EPA chronic and acute criteria (Sacramento NWR). Due to these test results it is believed that the use of this water could have a detrimental effect on the aquatic and wildlife resources that utilize the area. In addition, limited quantity (hundreds of gallons instead of thousands) was found for the test wells at Sacramento NWR. The groundwater basin under the Sacramento and Delevan refuges is considered to be of very limited usefulness.

*Groundwater plan*      No   X        Yes           .

*Groundwater basin(s) that underlie the refuge*

<i>Name of basin underlying refuge</i>	<i>Size (sq. mi.)</i>	<i>Usable capacity (AF)</i>	<i>Safe yield (AF/Y)</i>	<i>Management agency</i>	<i>Relevant reports</i>
Colusa Subbasin	1,434	900,000	NA	Colusa County	DWR Bulletin 118

*Identify refuge-operated ground water wells*

<i>#</i>	<i>Location</i>	<i>Status</i>	<i>HP</i>	<i>2003 (AFY)</i>	<i>Future plans</i>
None					

## Section E    Environmental Characteristics

1. *Topography - describe and discuss impact on water management*

Topography of Delevan NWR is relatively flat with a slope from NW to SE. The water impact of this gentle NW to SE slope is that the refuge takes all delivered water at the northwest corner which is used in all units as it gravity flows towards the east and south spill points.

2. *Soils - describe and discuss impact on water management (see attached map)*

The soils of Delevan NWR (Attachment D - Delevan National Wildlife Refuge Soils Map) are fairly tight soils that minimize seepage and are thus beneficial for wetland type habitats. There are no areas of problem soils so water management is very efficient.

### 3. Climate

*National Weather Service – Willows 6 W, California (049699), data period – 10/15/1906 to 7/31/2010*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
avg precip	3.72	3.18	2.28	1.13	0.65	0.32	0.04	0.09	0.31	0.98	2.13	3.16	17.99
avg. temp	45.2	49.7	53.5	58.8	66.3	73.5	78.0	76.1	72.5	64.3	53.3	45.9	61.40
avg. max temp	54.5	60.3	65.7	72.9	81.3	89.3	95.2	93.6	89.0	79.2	65.5	55.5	75.2
avg. min temp	35.9	39.0	41.3	44.8	51.3	57.6	60.9	58.7	56.0	49.3	41.1	36.3	47.7
ETo *	1.22	1.71	2.93	4.72	6.10	7.20	8.54	7.32	5.31	3.60	1.65	1.04	51.34

\* ETo data from Appendix B - Reference Crop Evapotranspiration for Willows, Glenn County, California at <http://esce.ucr.edu/soilwater/etodata.html>.

*Discuss the impact of climate, and any microclimates, on water management*

Climate can be characterized as mild damp winters and long hot summers. Refuge objectives result in the majority of wetlands being flooded during the fall and winter (to mimic historic hydrologic patterns). Those acres that remain flooded during spring and summer have the greatest amount of water used per habitat acre. The hot summers, and the resulting evaporative losses, require that permanent-water habitat be kept to a minimum. No microclimates exist within the refuge borders.

### 4. Water quality monitoring (attach water quality test result forms)

*If the refuge has a water quality monitoring program complete this table*

Analyses performed	Frequency range	Concentration range	Average
pH	Once	7.8 - 8.0	7.8
Dissolved solids	Once	193 - 399	302
Dissolved oxygen	Once	5.8 - 8.2	6.7
Alkalinity as CaCO <sub>3</sub>	Once	125 - 238	191
Calcium	Once	19 - 31	26
Chloride	Once	10 - 33	21
Magnesium	Once	13 - 26	20
Nitrogen	Once	<0.1 - 0.23	<0.14
Potassium	Once	1.3 - 2.1	1.7
Sodium	Once	28 - 77	55
Sulfate	Once	19 - 60	41
Arsenic	Once	1 - 3	1.8
Boron	Once	110 - 260	188
Cadmium	Once	All <1	<1
Chromium	Once	All <1	<1
Copper	Once	1 - 2	1.3
Lead	Once	<5 - 17	<7
Mercury	Once	All <0.1	<0.1
Molybdenum	Once	<1 - 1	<1
Selenium	Once	<1 - 5	<1.6
Uranium	Once	<0.4 - 1.5	<0.6
Vanadium	Once	3 - 6	4.2
Zinc	Once	<3 - 39	<17.8

*Discuss the impact of water quality on water management*

The refuge has no water quality monitoring program other than a baseline study (Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sacramento National Wildlife Refuge Complex) conducted in 1988 which found no water quality problems that would affect water management decisions. Data entered in the table above are based on that baseline study. Water management decisions are based on this baseline study since it is the only source of water quality data specific for the refuge.

## **Section F Transfers, Exchanges and Trades**

*Provide information on any transfers, exchanges and/or trades into or out of the refuge*

From whom	To whom	Report year (AF)	Use
None			
	<i>TOTAL</i>		

## **Section G Water Inventory**

### **1. Refuge Water Supplies Quantified**

Surface water supplies, imported and originating within the District, by month. Table 1

Ground water extracted by the Refuge, by month. Table 1

Precipitation by Habitat Type Table 3

Upslope Drain Water, by month. Table 1

Other supplies, by month Table 1

Refuge water inventory. Table 4

Ten-year history of Refuge water supplies Table 5

### **2. Water Used Quantified**

3. Conveyance losses, including seepage, evaporation, and operational losses. Table 2

4. Applied Habitat water, evapotranspiration, water used for cultural practices (e.g., disease control, etc.). Table 3

5. Estimated deep percolation (seepage) within Habitat areas. Table 3

6. Habitat spill or drain water leaving the Refuge. Table 4

See Attachment E – Delevan National Wildlife Refuge Water Inventory Tables

## Section H Critical Best Management Practices

Describe the 5-year implementation plan and the proposed 3-year funding budget.

### 1. Management programs

#### a. Education

Program	Estimated cost (in \$1,000s)		
	2011	2012	2013
Irrigator training – 4 staff	\$2	\$2	\$2
Interpretive displays	\$1	\$1	\$1
Environmental Education – 2 staff	\$58	\$59	\$60

*Describe the specifics of each program (number of participants, topics, purpose, etc.) and attach program materials, if available.*

These programs apply to all the refuges in the Sacramento NWR Complex. The four refuge irrigators are sent to training in distribution system management, flow control, turnout calibration and other aspects of water and wetland management. All refuge staff attend monthly staff/safety meetings during which the status and timing of wetland flood-up and drawdown schedules are discussed, in addition to other applicable water related topics (e.g. status of efforts to secure CVPIA water for Sutter NWR, irrigation district maintenance efforts and the effect on refuge water deliveries, etc.). The Environmental Education program hosts more than 5,000 students visiting each year. Topics covered during the Environmental Education programs include water and wetland habitat management. Interpretive displays on the refuges of the Complex include information on wetland management. New interpretive displays are purchased periodically and there is an on-going expense to maintain them. The Complex hosts an annual Wetland Management Workshop for landowners attended by 50-60 local landowners and duck club managers. Information concerning water management on the refuges of the Sacramento NWR Complex is being developed for inclusion on the Complex's website.

#### b. Water quality monitoring

Type of water	Existing Estimated cost (in \$1,000s)		
	2011	2012	2013
Surface – USBR and riparian	\$5.0	\$5.1	\$5.2
Upslope drain	NA	NA	NA
Groundwater	NA	NA	NA
Outflow	NA	NA	NA

*Short description of existing or planned program – i.e., required by which agency, coordinated with whom, constituents monitored and frequency*

The Refuge Complex is a member of the Colusa Sub-basin watershed of the Sacramento Valley Coalition for monitoring water quality. No water quality problems were identified during 2009-2010. Past studies (Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sacramento National Wildlife Refuge Complex. 1988; etc.) have indicated no surface water (inflow and outflow) quality issues.

c. *Cooperative efforts*

The Complex is working with GCID to improve water delivery and measurement (partially through the use of SCADA) capabilities to Sacramento, Delevan and Colusa refuges. The Complex is continuing to work with USBR to secure delivery for Sutter NWR.

d. *Pump evaluations (mobile labs) NA*

Total number of groundwater pumps on refuge 0

Total number of surface water (low-lift) pumps on refuge 0

Groundwater pumps	Estimated cost (in \$1,000s)		
	2011	2012	2013
# of groundwater pumps tested	NA	NA	NA
# of pumps to be fixed or replaced	NA	NA	NA
# of low-lift pumps to be tested	NA	NA	NA
# of pumps to be fixed or replaced	NA	NA	NA

e. *Policy evaluation*

1. The right to move unused allocated water between refuges within our complex, to other CVP refuges, to CDFG, and to other CVP contractors.
2. FWS joins Seven Party Agreement so that outflow (into a canal/drain) from upstream refuges (e.g. Sacramento NWR) is available for diversion to downstream refuges at no charge. This would keep the US government (USBR) from having to buy the same water multiple times.

f. (GRCD only) ~~*Provide Customer Services—Facilitate physical/structural improvements for member units; provide management services and technical advice to raise funds for BMP Implementation and provide customers with water efficiency education programs.*~~

2. (GRCD only) ~~*Pricing structure*~~

3. (GRCD only) ~~*Plan to measure deliveries*~~

4. *Water management coordinator*

Name: Steven R. Emmons Title: Wildlife Refuge Manager

Address: 752 County Road 99W, Willows, CA 95988

Telephone: 530-934-2801 E-mail: steve\_emmons@fws.gov

## Section I Exemptible Best Management Practices

Describe the 5-year implementation plan and the proposed 3-year funding budget.

1. *Improve management unit configuration*

Unit name	Current acres	Reason for change	Proposed acres	Estimated cost (in \$1,000s)		
				2011	2012	2013
See comment below						

Changes to unit configuration are determined if needed during the annual habitat management planning cycle.

*(GRCD only) Assist customers to improve management unit configurations.*

2. *Improve internal distribution system*

a. *New control structures within distribution system*

<i>Proposed location</i>	<i>Type of structure</i>	<i>Reason for new structure</i>	<i>Estimated cost (in \$1,000s)</i>		
			<i>2011</i>	<i>2012</i>	<i>2013</i>
6 yearly – locations TBD	concrete	Replace old CMP control structures	\$6	\$6.5	\$7
T5.5 siphon	concrete	Replace damaged CMP structure	\$3	\$0	\$0
See comment below					

Changes to distribution system are determined if needed during the annual habitat management planning cycle. Usually 6-8 existing corrugated metal pipe (CMP) water control structures are replaced annually with the locations determined during the annual habitat management planning cycle or as problems arise with a structure beginning to fail during the course of the year.

b. *Line/pipe sections of distribution system*

<i>Proposed reach/sect.</i>	<i>Reason for new structure</i>	<i>Estimated cost (in \$1,000s)</i>		
		<i>2011</i>	<i>2012</i>	<i>2013</i>
See comment below				

Changes to distribution system are determined if needed during the annual habitat management planning cycle. There is limited opportunity for lining or piping sections of the distribution system on the refuge because the existing open distribution system provides some of the most consistently used habitat by giant garter snakes, a federally listed threatened species. This habitat would be lost if the system was lined or piped. However, this BMP is occasionally implemented on limited portions of the distribution system, with the locations identified during the annual habitat management planning cycle.

c. *Independent water control for each unit*

<i>Proposed control point</i>	<i>Reason for new control point</i>	<i>Estimated cost (in \$1,000s)</i>		
		<i>2011</i>	<i>2012</i>	<i>2013</i>
See comment below				

Changes to unit configuration and distribution system are determined if needed during the annual habitat management planning cycle.

d. *New internal distribution sections (pipe, canal) to provide water to existing and new habitat units*

<i>Proposed new section</i>	<i>Units served</i>	<i>Reason for new section</i>	<i>Estimated cost (in \$1,000s)</i>		
			<i>2011</i>	<i>2012</i>	<i>2013</i>
See comment below					

Changes to distribution system are determined if needed during the annual habitat management planning cycle.

*(GRCD only) Provide assistance to member units to improve internal distribution*



### 3. Develop a Water Use Schedule

Plan element	Completion date	Estimated development/update cost (in \$1,000s)		
		2011	2012	2013
Floodup dates by unit	Completed annually	\$1	\$1	\$1
Drawdown dates by unit	Completed annually	\$1	\$1	\$1
Irrigation dates by unit	Completed annually	\$1	\$1	\$1

Floodup dates, drawdown dates and irrigation dates (where appropriate) are developed for each unit during the annual habitat management planning cycle.

### 4. Plan to measure outflow

*Identify locations, prioritize, determine best measurement method/cost, submit funding proposal*

	Estimated cost (in \$1,000s)		
	2011	2012	2013
Identify locations			
Estimate outflow quantity/rank			
Develop plan			
Estimate construction start date			
Estimate construction completion date			

Currently, five potential sites have been identified for meters (two in Tract 25, one in the southeast corner of Tract 43 [SE Corner], and two in the East Drain) which would enable measuring outflow from approximately 79 percent of the refuge wetlands. A project to fund the installation of metering structures on these five priority sites and another project to fund metering structures for the remaining outflow locations have been submitted through the FWS Service Asset Maintenance and Management System (SAMMS). The projects have not been identified for FWS funding within the current 5-year funding cycle. Changes to the funding status of these projects, or other funding opportunities, will be identified in the annual updates to this plan.

### 5. (GRCD only) ~~Incentive pricing~~

### 6. Construct and operate operational loss recovery systems

Proposed location	Reason for improvement	Estimated cost (in \$1,000s)		
		2011	2012	2013
See comment below				

FWS is exploring the possibility of joining the Seven Party Agreement so that outflow/spill from upstream refuges can be credited to downstream diversions. Outflow credits could be used to fund outflow/spill measurement programs.

### 7. Optimize conjunctive use of surface and groundwater

Proposed production/injection well	Anticipated yield	Estimated cost (in \$1,000s)		
		2011	2012	2013
NA – no useable groundwater				
See comment below				

Although no groundwater quality testing has been conducted at Delevan NWR, chemical analysis of groundwater wells at nearby Sacramento NWR and Colusa NWR conducted in the early 1990s detected mercury levels above the EPA chronic criteria (both Sacramento NWR and Colusa NWR) and levels of the hexavalent form of chromium above the EPA chronic and acute criteria (Sacramento NWR). Due to these test results it is believed that the use of this water could have a detrimental effect on the aquatic and wildlife resources that utilize the area. In addition, limited quantity (hundreds of gallons instead of thousands) was found for the test wells at Sacramento NWR. The groundwater basin under the Sacramento and Delevan refuges is considered to be of very limited usefulness.

8. *Facilitate use of available recycled urban wastewater that otherwise would not be used beneficially, meets all health and safety criteria, and does not cause harm to wildlife management goals.*

NA - no recycled urban wastewater is available

9. *Mapping – COMPLETE*

See Attachment C – Delevan National Wildlife Refuge Water Delivery and Drainage Map, and Delevan National Wildlife Refuge Water Drainage Areas Map.

<i>GIS map layers</i>	<i>Estimated cost (in \$1,000s)</i>		
	<i>2011</i>	<i>2012</i>	<i>2013</i>
Map 1 – Water Delivery and Drainage Map	\$0	\$0	\$0
Map 2 – Water Drainage Areas Map	\$0	\$0	\$0

10. *CALFED Quantifiable Objectives*

*Describe any past, present, or future plans that address the goals identified for this refuge*

*If reducing nonproductive ET involves removing invasive plants, complete the following:*

<i>Invasive unwanted species name</i>	<i>Estimated acres</i>			<i>Estimated cost (in \$1,000s)</i>		
	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>
Arundo	2	2	2	\$1	\$1	\$1
Salt cedar	2	2	2	\$1	\$1	\$1
Water primrose	19	20	20	\$6.5	\$7	\$7.5

Sacramento and Delevan National Wildlife Refuges (NWRs)

1. Describe actions that reduce the salinity of surface return water. (Targeted Benefit (TB) 24)

None - no salinity or conductivity problems have been documented on any of the refuge's wetlands.

2. Describe actions that reduce nonproductive ET. (TB 25)

The refuge has a continuous program to minimize or eradicate invasive aquatic plants (primrose, salt cedar and Arundo).

**Attachment A**

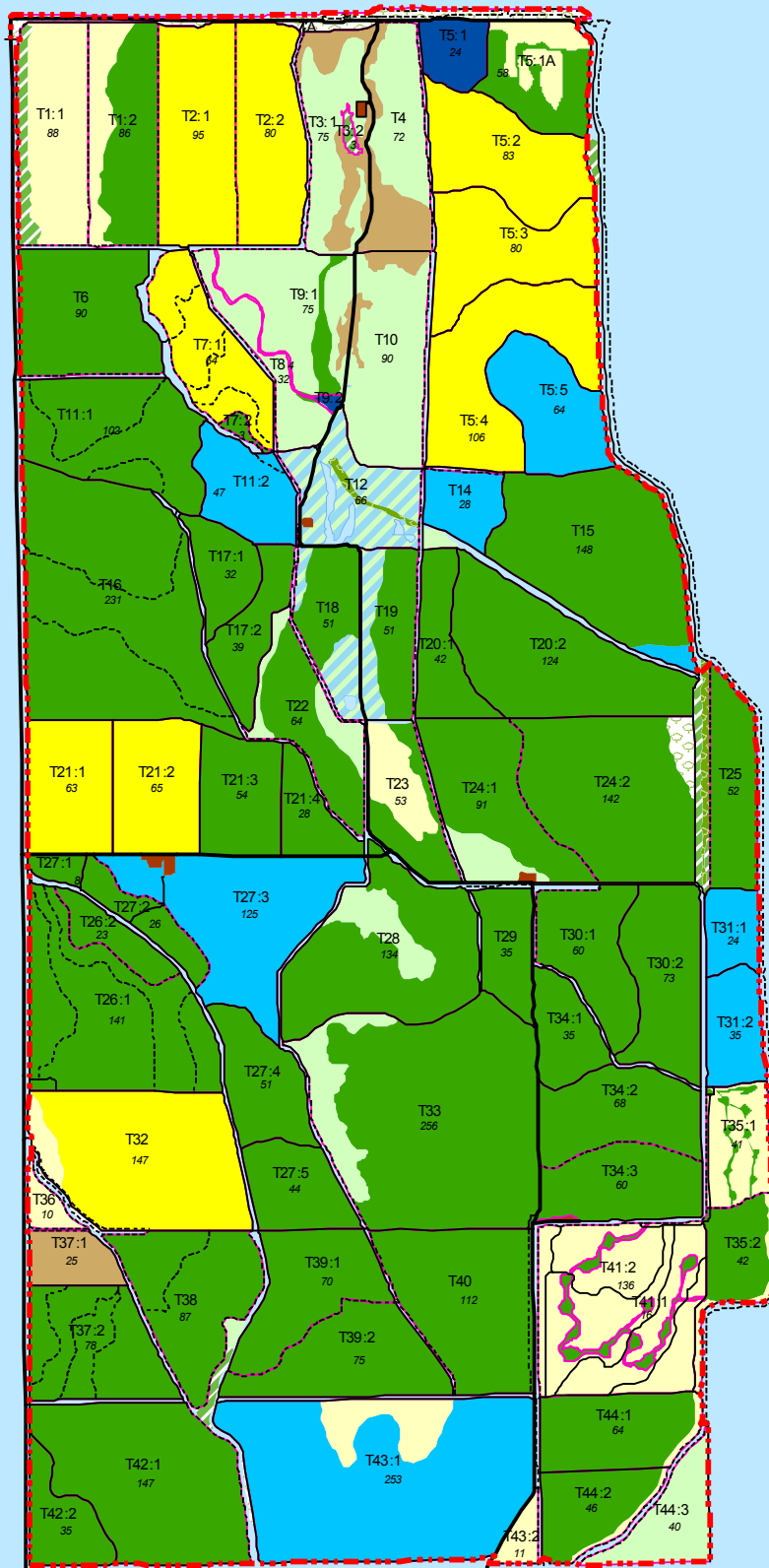
Delevan National Wildlife Refuge

Habitat Map

February 9, 2011

# Delevan NWR

## Habitat Management 2010-11



### Refuge Boundary

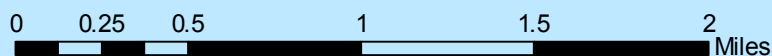
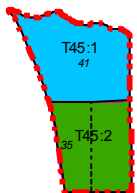
### Roads

- All Weather
- Standard Dirt
- - - - - Non-Drivable
- Cell Boundaries (no roads)

### Habitat Management 2010-11

- Seasonal Flooded Marsh
- Unmanaged Freshwater Wetland
- Watergrass
- Summer Water
- Permanent Pond
- Vernal Pool
- Alkali Meadow
- Vernal Pool/Alkali Meadow Complex
- Riparian Willow Scrub
- Cottonwood Willow
- Mixed Riparian Forest
- Annual Grassland
- Perennial Grassland
- Facilities
- Fallow

### Rennick Property



**Attachment B**

Delevan National Wildlife Refuge

Drought Contingency Plan

February 9, 2011

# Sacramento National Wildlife Refuge Complex – Delevan NWR

## Drought Contingency Plan

### February 2011

In the event of reduced water allocations, the refuges of the Sacramento National Wildlife Refuge Complex wetland management practices will be adjusted according to the severity of the water reduction as well as the timing within the water year when the cutback is finalized. Dry year and critically dry year water allocations are based upon the Shasta Lake Index and approximate allocations can be found in Tables 1-4.

Adjustments to wetland management practices and their potential impacts to the wetlands of the refuges are identified below for four anticipated water availability scenarios (See Tables 1-4 and Figures 1-4).

#### A. 100% Level 2 at Sacramento, Delevan, Colusa NWR's & Level 4 (Delevan NWR)

1. Normal spring draw-downs would provide habitat suitable for shorebird habitat/use and plant germination objectives being met.
2. Standard acres of permanent ponds and summer water (approximately 5-15% of total managed wetlands on each refuge) would be managed for use by giant garter snakes, tricolored blackbirds, western pond turtles, and duck broods.
3. Standard number of irrigated acres for annual food plant production (approximately 12-15% of total managed wetlands on each refuge) and control of invasive species (e.g. cocklebur).
4. Flood-ups start in late July and total wetland acres would be flooded by early November.
5. Standard wetland habitat maintenance water supply would be available.
6. Visitor Services programs (i.e. hunting, wildlife observation, wildlife photography, interpretation, and environmental education) that support 100,000 to 125,000 visitors would be fully operational.

#### B. 75% Level 2 at Sacramento, Delevan, Colusa NWR's & Level 4 (Delevan NWR)

1. Earlier spring draw-downs than normal due to less maintenance water available, resulting in less shorebird habitat and poorer plant germinations.
2. Permanent pond acres decreased by 50% and summer water acres by 25% potentially negatively impacting garter snakes, tricolored blackbirds, and western pond turtles.
3. 10% decrease in acres irrigated for annual food plants and to control invasive species such as cocklebur. There would be an increase in acres mowed, resulting in more diesel consumption, to mitigate for the decreased control of invasive species by irrigating.
4. Flood-ups would be delayed on a number of wetlands resulting in less habitat available for early migrants, and increased potential for crop depredation (Lea Act consideration at Colusa NWR). Water would be shifted from Sacramento and Colusa refuges to Delevan NWR. Wetland flood-ups would not be completed until late November.

5. Total wetland acres would be reduced by at least 10% with potential longer term impacts to future wetland quality.

6. Concentration of waterfowl on reduced habitat acres would increase disease risk, particularly with other public/private wetland acres anticipated to be reduced as well.

7. Standard habitat maintenance water supplies planned for use on the reduced wetland acres.

8. Reduced visitor use due to lower hunter quotas early in the hunting season before wetland units are flooded, a few auto tour units being dry, etc.

C. 50 % Level 2 at Sacramento, Delevan, Colusa NWR's & Level 4 (Delevan NWR)

1. Early spring draw-downs resulting in much less shorebird habitat available and poor plant germinations due to reduced maintenance supplies,

2. Permanent pond acres decreased by 75% and summer water decreased by 50% with associated significant impacts to giant garter snakes, tricolored blackbirds, western pond turtles, and duck broods.

3. 50% decrease in acres irrigated for annual food plants and control of invasive species such as cocklebur, with increased mowing/diesel use to mitigate.

4. Flood-ups delayed on an increased number of wetlands with significantly increased potential for crop depredation, problems likely near refuges (Lea Act consideration at Colusa NWR). Wetland flood-ups would not be completed until early December.

5. Total wetland acres reduced 30-50% with longer-term impacts to future wetland quality on more acres.

6. Significantly increased waterfowl crowding and associated disease risk due to the reduced habitat available. Other public/private wetland acres would be reduced significantly.

7. Standard habitat maintenance water supplies planned for use on vastly reduced number of wetland acres.

8. The hunting program on all three refuges would be eliminated, the auto tour at Colusa NWR would be closed, and visitor use on the Sacramento NWR auto tour would be reduced by 50% due to poorer viewing opportunities. Overall visitor use would drastically decrease.

D. 25% Level 2 at Sacramento, Delevan, Colusa NWR's & Level 4 (Delevan NWR)

1. Very early spring draw-downs would result in severely limited shorebird habitat and poor plant germinations due to reduced maintenance water supplies,

2. Permanent pond acreage decreased by 80% and summer water decreased by 80% with even more dramatic impact of giant garter snakes, tricolored blackbirds, western pond turtles, and duck broods.

3. Complete elimination of irrigations for annual food plants and control of invasive species resulting in vastly increased mowing/diesel fuel consumption to mitigate.

4. Flood-ups delayed even later on what few acres that could be flooded. Significant widespread crop depredation would be almost a certainty (Lea Act considerations at Colusa NWR). Water would be shifted from Colusa NWR to Sacramento NWR. Wetland flood-ups would be completed by mid-December.



5. Total wetland acres reduced 60-70% with longer-term impacts to future wetland quality on a vast majority of refuge wetlands.
6. Extreme waterfowl crowding and disease risk, particularly since there would be minimal other public/private wetlands available.
7. Uncertain habitat maintenance water supply on what few acres we are able to flood-up.
8. Public use on all refuge habitats would be eliminated, other than having the Sacramento NWR visitor center open. Visitor use would decrease to a fraction of normal.

**TABLE 1. 100% ANTICIPATED WATER USE SCHEDULE - Sacramento NWR Complex**

Mon	Sacramento NWR (all Level 2)	Delevan NWR			Colusa NWR (all Level 2)
	Total	Level 2	Level 4	Total	Total
March	1,250	400	0	400	1,500
April	1,740	600	0	600	1,000
May	1,930	1,200	0	1,200	1,000
June	2,130	1,000	0	1,000	1,500
July	2,400	600	0	600	1,000
August	5,000	2,200	1,000	3,200	1,000
September	9,050	4,300	1,300	5,600	4,000
October	9,900	4,150	1,450	5,600	5,000
November	6,300	3,800	0	3,800	3,500
December	3,500	2,000	0	2,000	3,000
January	2,000	700	0	700	1,500
February	1,200	0	0	0	1,000
Total	46,400	20,950	3,750	24,700	25,000

**TABLE 2. 75% ANTICIPATED WATER USE SCHEDULE - Sacramento NWR Complex**

Mon	Sacramento NWR (all Level 2)	Delevan NWR			Colusa NWR (all Level 2)
	Total	Level 2	Level 4	Total	Total
March	350	250	0	250	700
April	100	300	0	300	400
May	1,150	500	0	500	700
June	1,250	400	0	400	700
July	1,550	200	0	200	400
August	4,250	2,200	450	2,650	400
September	7,700	4,000	900	4,900	3,000
October	8,350	4,050	900	4,950	4,500
November	4,400	3,700	0	3,700	3,000
December	2,400	1,700	0	1,700	3,000
January	1,300	412	0	412	1,500
February	0	0	0	0	450
Total	32,800	17,712	2,250	19,962	18,750

NOTE: Delevan NWR Level 2 includes 2,000 AF from Sacramento NWR Level 2

Year 2009-10

**TABLE 3. 50% ANTICIPATED WATER USE SCHEDULE - Sacramento NWR Complex**

Mon	Sacramento NWR (all Level 2)	Delevan NWR			Colusa NWR (all Level 2)
	Total	Level 2	Level 4	Total	Total
March	500	1,100	0	1,100	1,200
April	900	400	0	400	400
May	500	250	0	250	250
June	1,400	750	0	750	700
July	800	200	0	200	200
August	1,800	675	500	1,175	150
September	3,500	1,000	500	1,500	1,500
October	6,600	2,300	500	2,800	4,000
November	4,800	2,000	0	2,000	2,000
December	1,200	600	0	600	700
January	1,200	600	0	600	700
February	0	600	0	600	700
Total	23,200	10,475	1,500	11,975	12,500

**TABLE 4. 25% ANTICIPATED WATER USE SCHEDULE - Sacramento NWR Complex**

Mon	Sacramento NWR (all Level 2)	Delevan NWR			Colusa NWR (all Level 2)
	Total	Level 2	Level 4	Total	Total
March	250	500	0	500	625
April	450	100	0	100	75
May	250	50	0	50	70
June	700	50	0	50	140
July	400	50	0	50	140
August	900	300	250	550	70
September	2,000	500	250	750	700
October	3,800	1,800	250	2,050	810
November	2,900	1,000	0	1,000	1,400
December	600	300	0	300	350
January	600	287	0	287	310
February	0	300	0	300	310
Total	12,850	5,237	750	5,987	5,000

NOTE: Sacramento NWR Level 2 includes 1,250 AF from Colusa NWR Level 2

# Delevan NWR

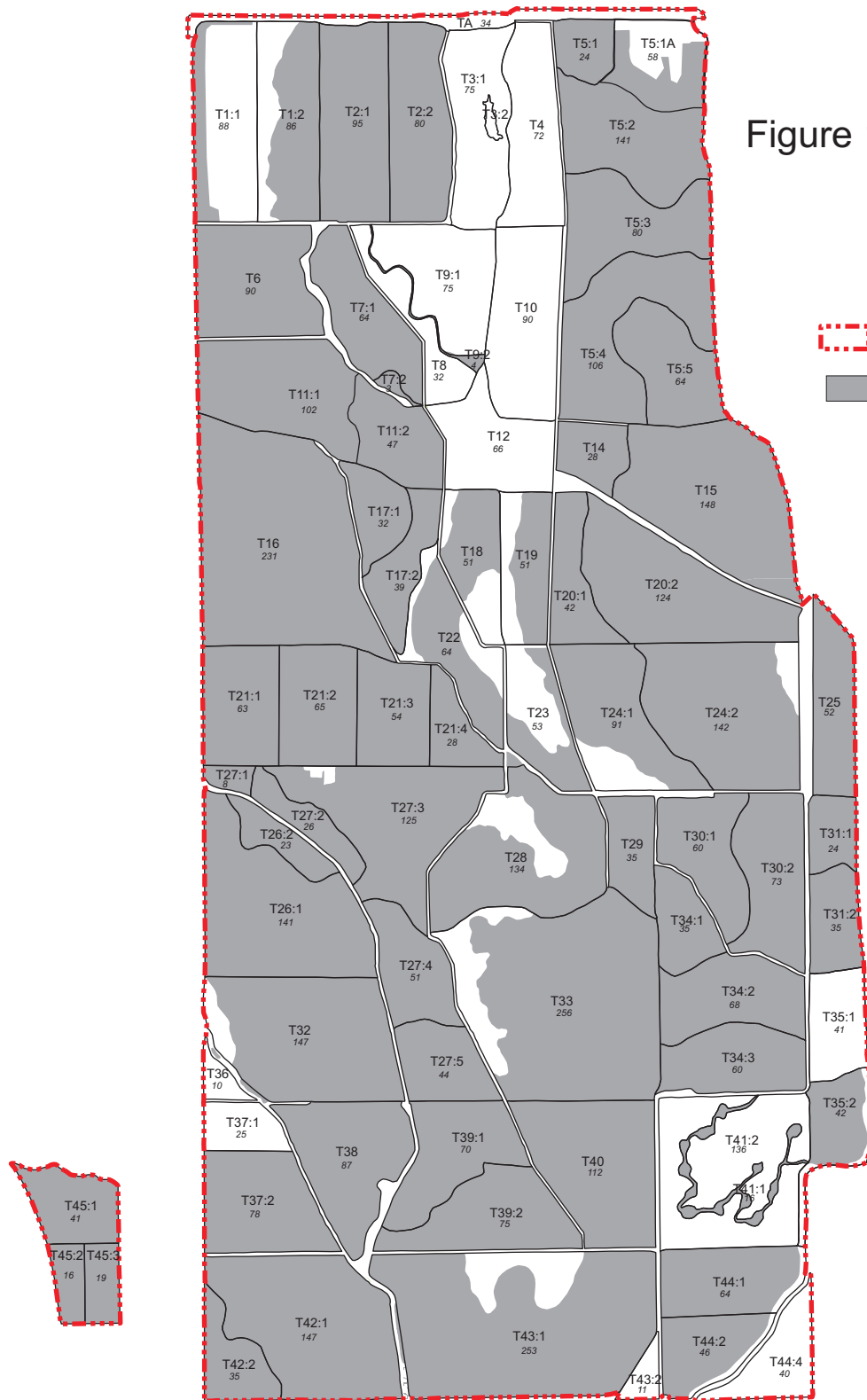


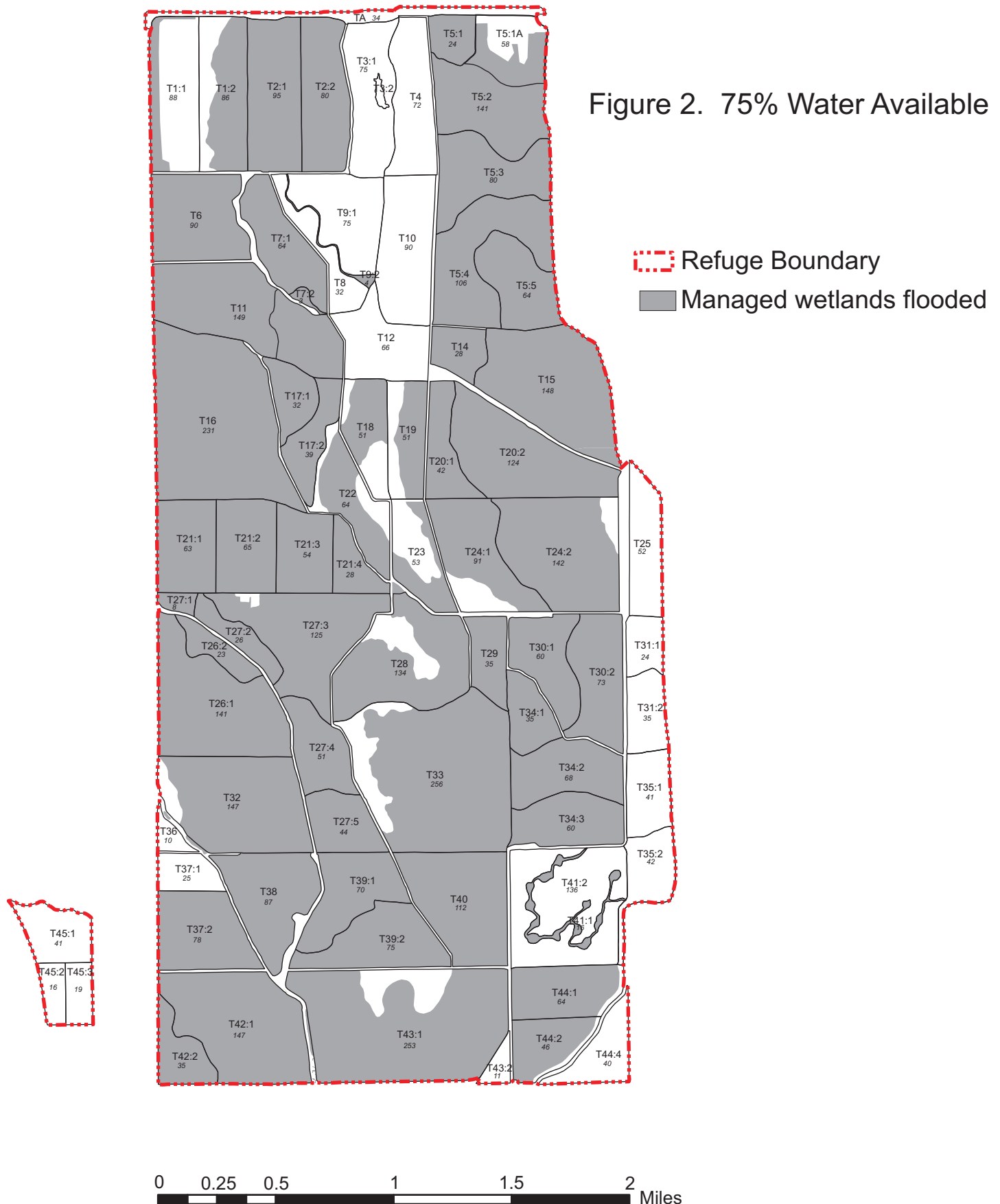
Figure 1. 100% Water Available

- Refuge Boundary
- Managed wetlands flooded



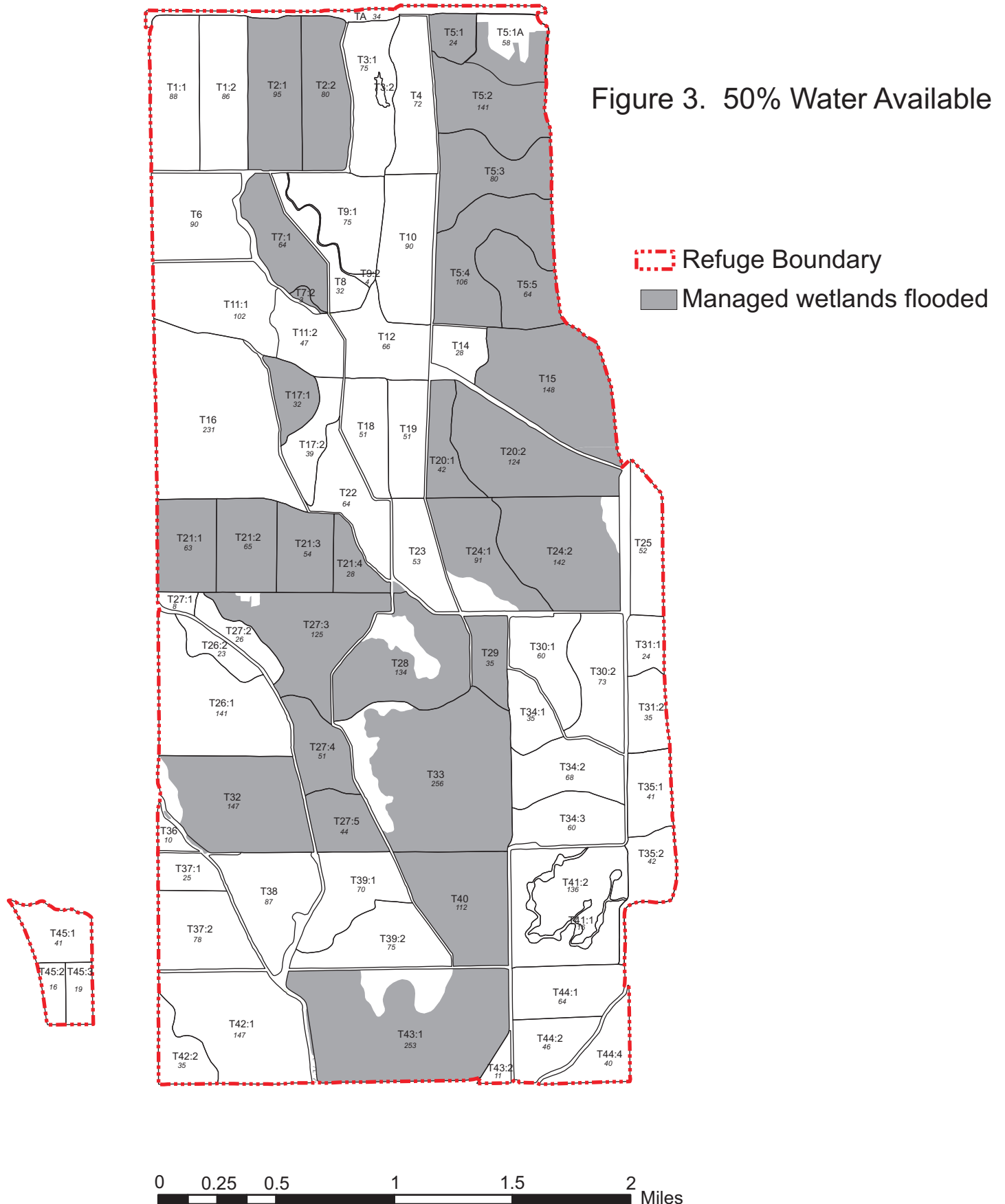
# Delevan NWR

Figure 2. 75% Water Available



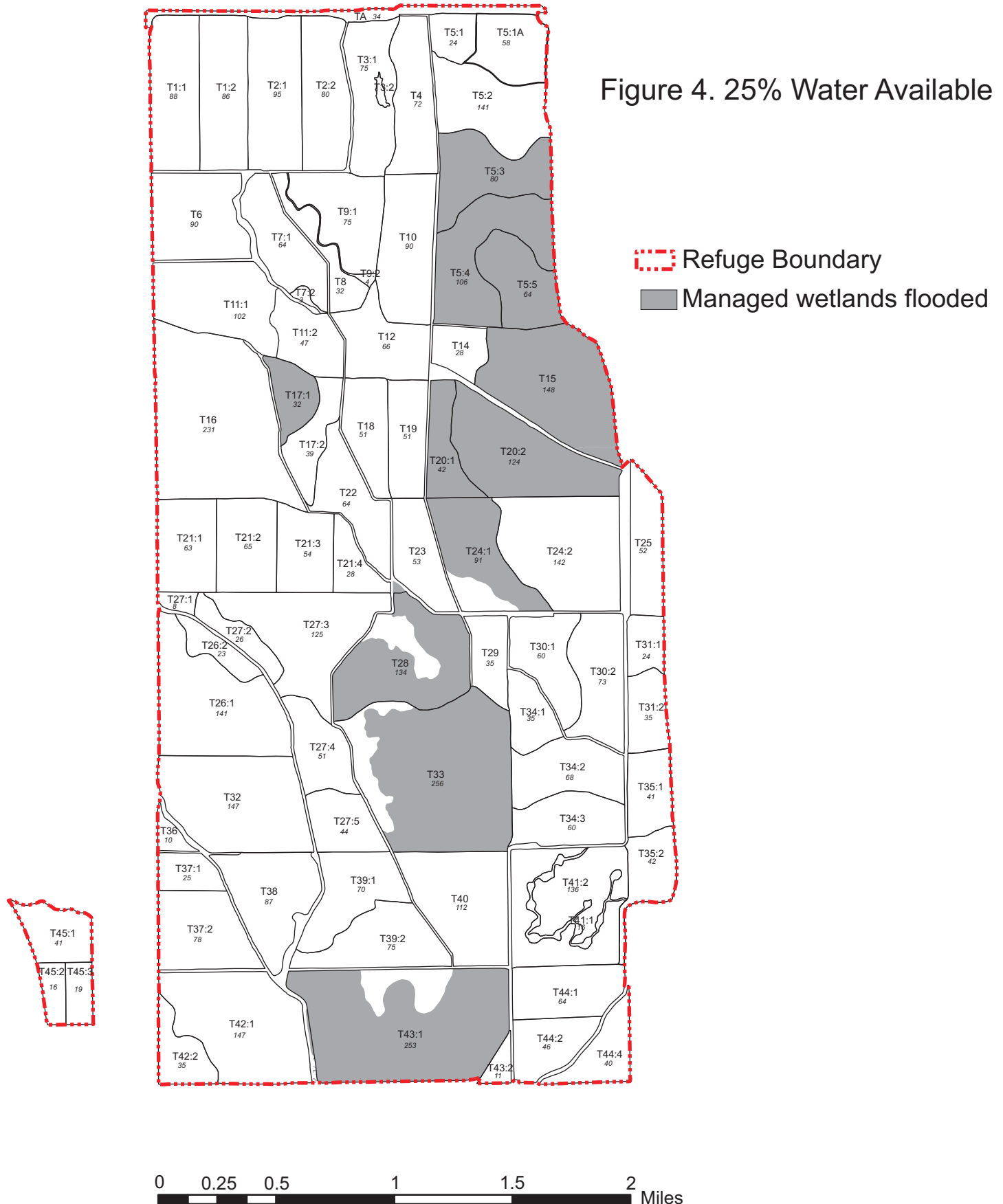


# Delevan NWR



# Delevan NWR

Figure 4. 25% Water Available



**Attachment C**

Delevan National Wildlife Refuge

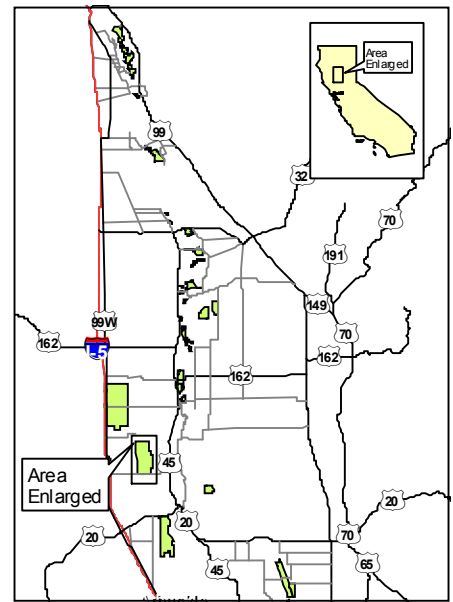
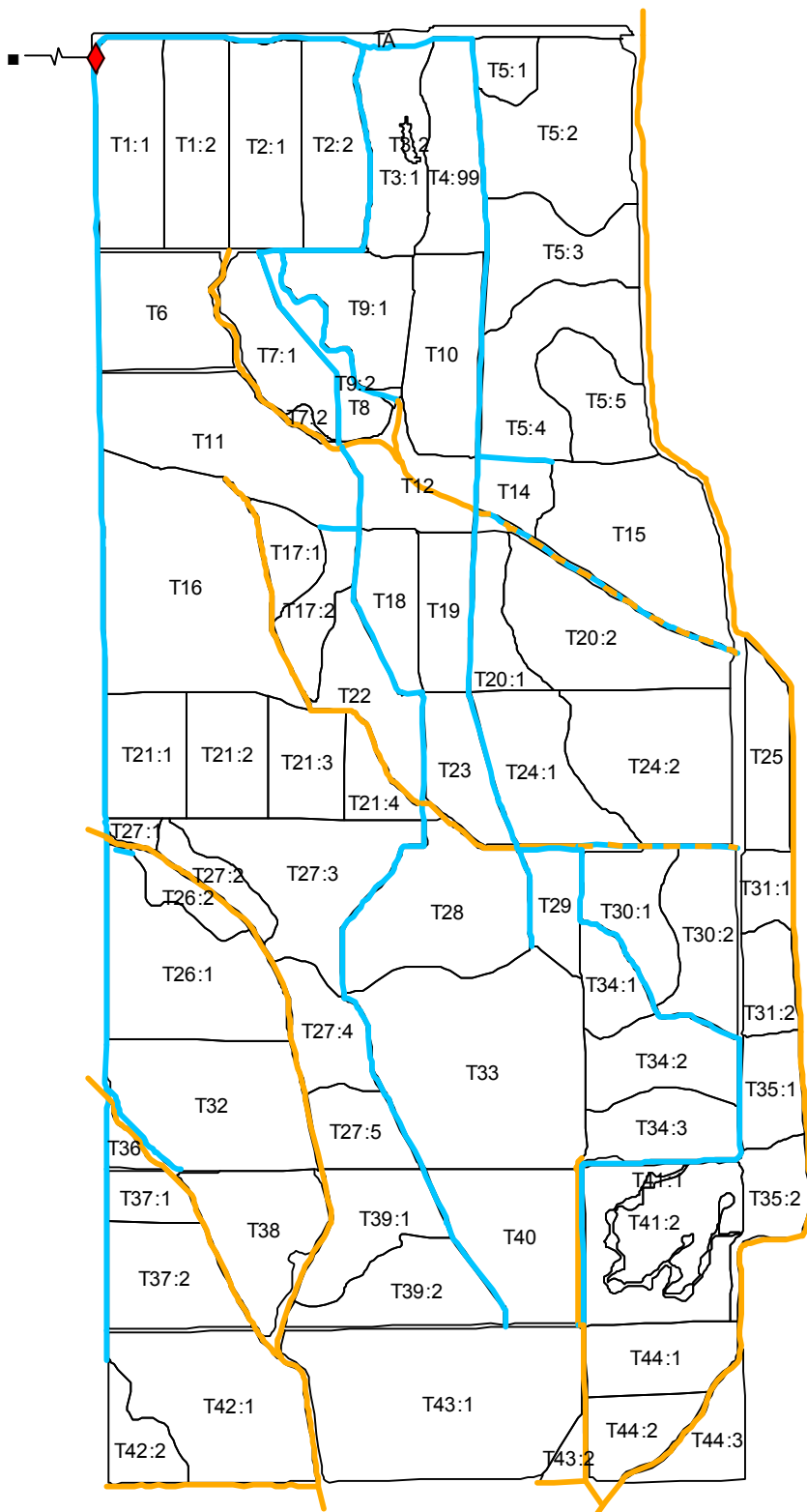
Water Delivery and Drainage Map

Water Drainage Areas Map

Water System Map

February 9, 2011

# Delevan National Wildlife Refuge



## Water Delivery

- Primary Delivery
- - - Delivery and Drain
- Drain
- ◆ Point of Delivery
- Meter Locations

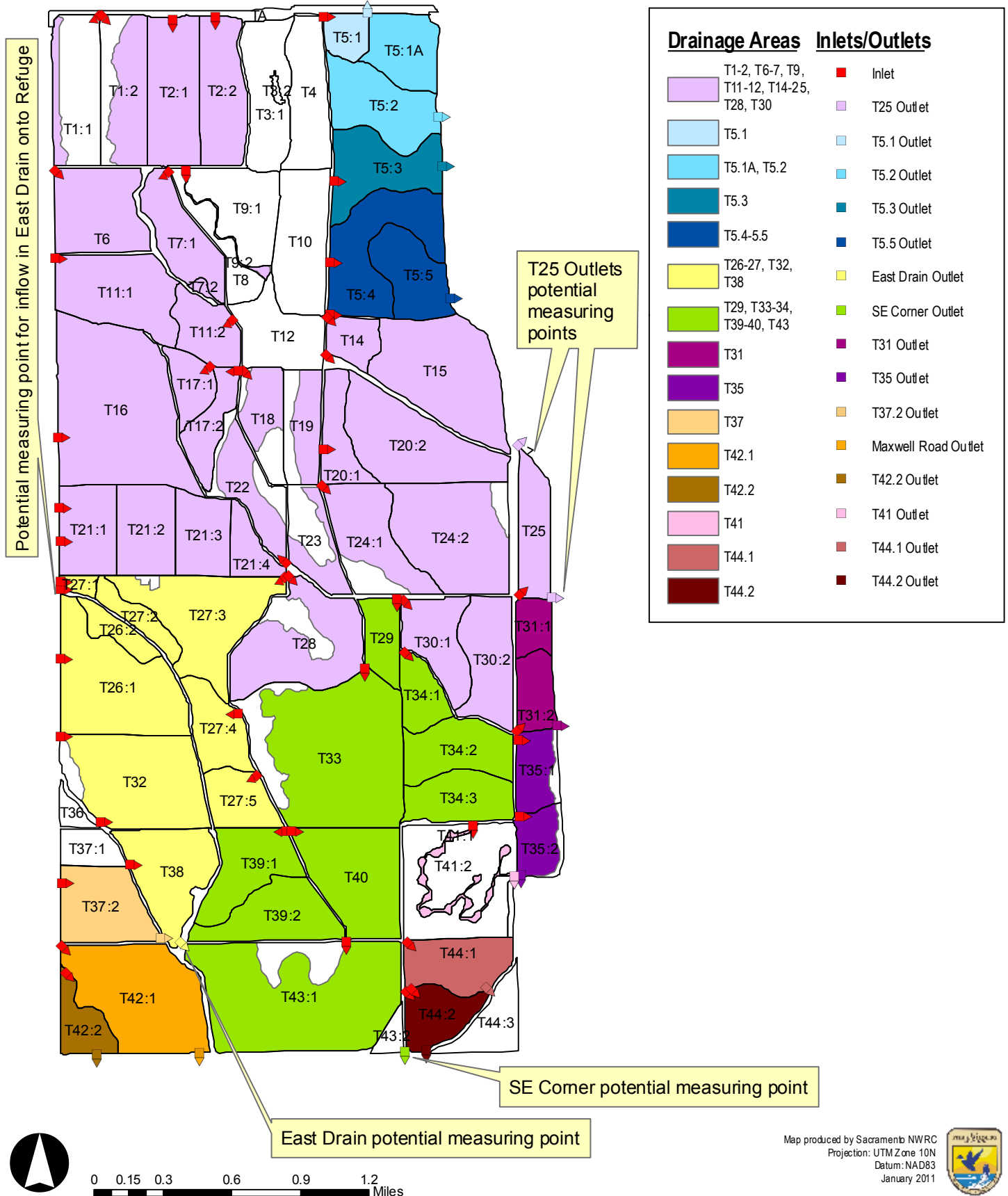


0 0.25 0.5 1 1.5 2 Miles

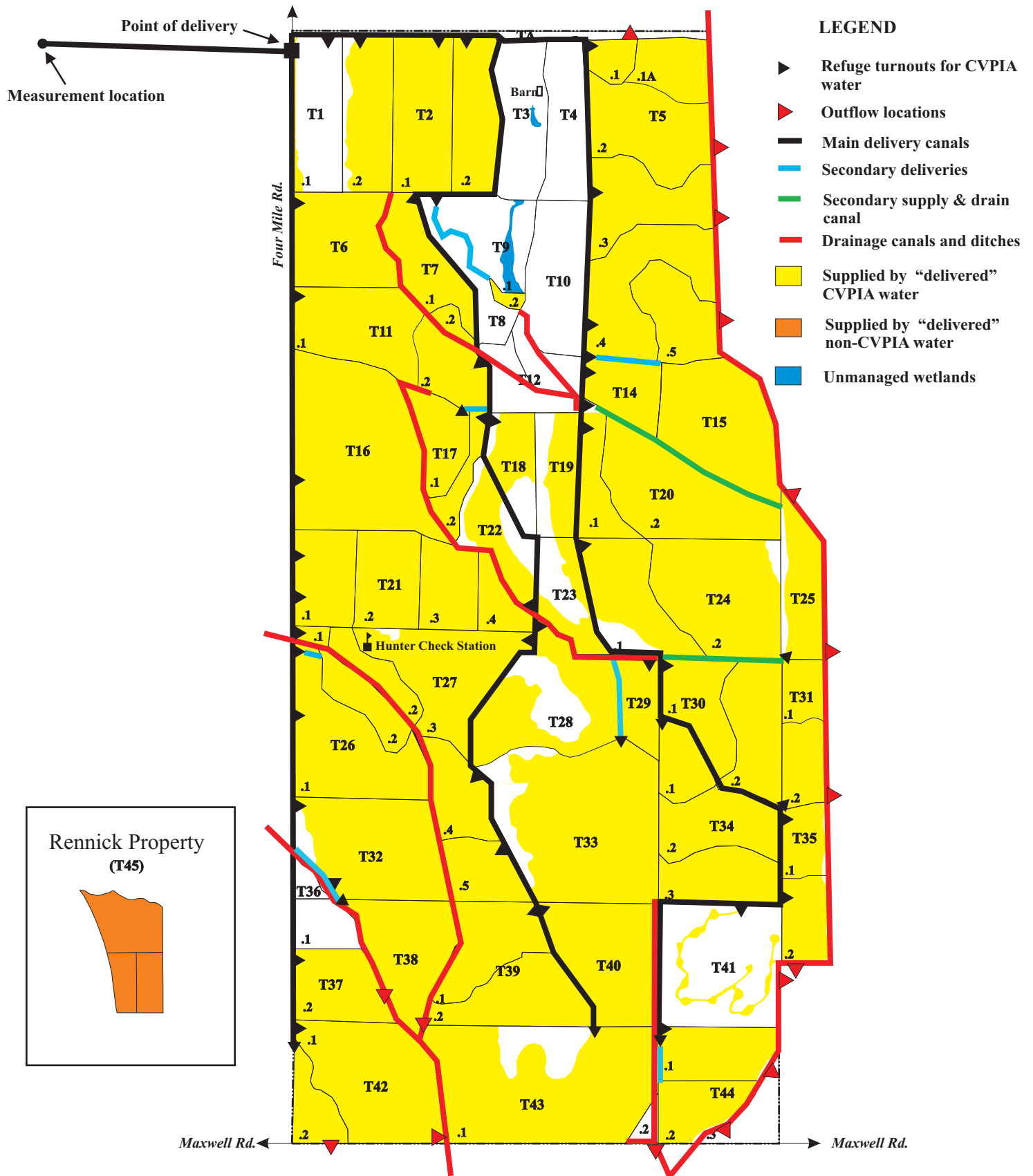
Map produced by Sacramento NWRC  
 Projection: UTM Zone 10N  
 Datum: NAD83  
 November 2005



# Delevan National Wildlife Refuge



# DELEVAN NATIONAL WILDLIFE REFUGE



**Attachment D**

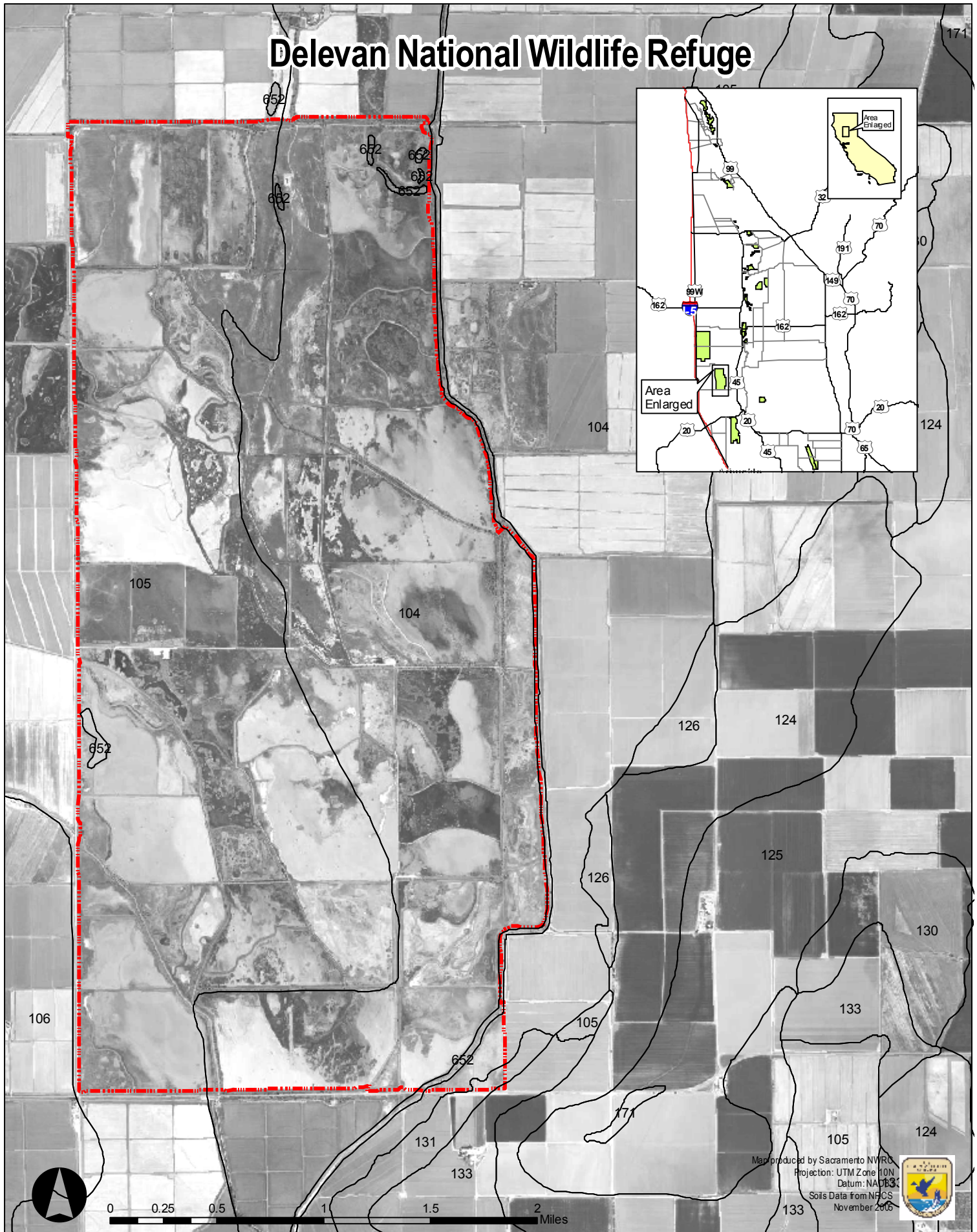
**Delevan National Wildlife Refuge**

**Soils Map**

February 9, 2011



# Delevan National Wildlife Refuge



## **Delevan National Wildlife Refuge Soil Series/Types\***

### **Colusa County**

104 = Willows Silty Clay, 0 to 1 percent slopes, frequently flooded

105 = Willows Silty Clay, 0 to 1 percent slopes, occasionally flooded

131 = Corbiere Silt Loam, 0 to 2 percent slopes, frequently flooded

652 = Water

\* from USDA Map Unit Legend Summary for Colusa County, California on NRCS Web Soil Survey.

**Attachment E**

**Delevan National Wildlife Refuge**

**Water Inventory Tables**

February 9, 2011

Table 1

Water Supply							
2009	Federal Wtr Level 2	Federal Wtr Level 4	Local Water Supply	Refuge Groundwtr	Up Slope Drain Wtr	other (define)	Total
	(acre-feet)	(acre-feet)	(acre-feet)	(acre-feet)	(acre-feet)	(acre-feet)	(acre-feet)
Method							
Jan-2010	1,011	0	0	0	0	0	1,011
February	0	0	0	0	0	0	0
Mar-2010	0	0	0	0	0	0	0
April	116	0	0	0	0	0	116
May	1,495	0	0	0	0	0	1,495
June	1,386	0	0	0	0	0	1,386
July	500	0	0	0	0	0	500
August	1,902	565	0	0	0	0	2,467
September	3,548	1,300	0	0	0	0	4,848
October	3,500	1,450	0	0	0	0	4,950
November	3,105	0	0	0	0	0	3,105
December	2,031	0	0	0	0	0	2,031
TOTAL	18,594	3,315	-	-	-	-	21,909

\*March 1, 2009 - February 28, 2010

Measurement Method Definitions:

- M1Measured summation from calibrated measuring devices, accurate to within +/- 6 percent.
- M2Measured summation from calibrated measuring devices.
- M3Measured summation from measuring devices.
- C1Calculated (more than summation) using information from calibrated devices (such as the difference between measurements upstream and down stream of diversion).
- C2Calculated using information from measuring devices.
- C3Calculated using estimates from pump run-times and pump efficiency.
- E1Estimated using measured information from similar conditions.
- E2Estimated using historical information.
- E3Estimated using observation.
- O1Other (attach a note with descriptions of other methods used).





**Table 4*****Refuge Water Inventory***

Year	2009	Reference	
Total Water Supply	Table 1		21,909
Precipitation	Table 2	plus	46
Evaporation	Table 2	minus	114
Seepage	Table 2	minus	3,000
Operational Losses	Table 2	minus	1,300
		Deliveries to Managed Lands	17,540
Managed Land needs	Table 3	minus	29,850
<b>Difference</b>	(calculated)		(12,310)
		Balance (outflow?) (Table 3)	(6,380)
		Water Inventory Balance	(18,690)

**Table 5*****Annual Water Quantities Delivered Under Each Right or Contract***

<b>Year</b>	<b>Federal Wtr Level 2 (acre-feet)</b>	<b>Federal Wtr Level 4 (acre-feet)</b>	<b>Local Water Supply (acre-feet)</b>	<b>Refuge Groundwtr (acre-feet)</b>	<b>Up Slope Drain Wtr (acre-feet)</b>	<b>other (define) (acre-feet)</b>	<b>Total (acre-feet)</b>
<b>2001</b>	19,570	0	0	0	0	0	<b>19,570</b>
<b>2002</b>	19,621	1,500	0	0	0	0	<b>21,121</b>
<b>2003</b>	16,969	5,355	0	0	0	0	<b>22,324</b>
<b>2004</b>	16,898	5,308	0	0	0	0	<b>22,206</b>
<b>2005</b>	19,179	3,750	0	0	0	0	<b>22,929</b>
<b>2006</b>	21,953	3,750	0	0	0	0	<b>25,703</b>
<b>2007</b>	19,156	3,750	0	0	0	0	<b>22,906</b>
<b>2008</b>	19,974	3,750	0	0	0	0	<b>23,724</b>
<b>2009</b>	18,594	3,315	0	0	0	0	<b>21,909</b>
<b>2010</b>	18,594	3,315	0	0	0	0	<b>21,909</b>
<b>Total</b>	<b>190,508</b>	<b>33,793</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>224,301</b>
<b>Average</b>	<b>19,051</b>	<b>3,379</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>22,430</b>